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OBSERVATIONS *on the* THEORY *of* ELECTRIC ATTRACTION *and* REPULSION. *By the Rev.* GEORGE MILLER, *F. T. C. D.*

BEFORE that the theory of a ſingle electric fluid was propoſed, no difficulty occurred in the explanation of the attractions and repulſions obſerved to ariſe from electricity. If we admit that there are two diſtinct electric fluids, each of which ſtrongly attracts the other, but conſiſts of particles mutually repulſive; it becomes eaſy to account for the attraction ſubſiſting between bodies in different ſtates of electricity, and the repulſion between thoſe in the ſame. But when Dr. Franklin*, obſerving that a man, ſtanding upon a non-conductor, could not electrify himſelf, but that he could electrify another perſon alſo ſtanding upon a non-conductor, was induced to regard the operation of exciting electricity only as a transfer of one and the ſame fluid from one body to another; it was found to be difficult to reconcile to the new theory the mutual repulſion of bodies in that ſtate which is, according to this theory, denominated

Read Jan. 5th, 1799.

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* Dr. Prieſtley's Hiſtory of Electricity, p. 161.

denominated negative electricity. Doctor Franklin* acknowledged that he could not aſſign a ſatisfactory reaſon for it; and Doctor Prieſtley † has propoſed it, as one of the queries remaining to be ſolved for completing the ſcience of electricity. Many attempts have been made to obviate this apparent objection to the ſimple theory of a ſingle fluid; but the difficulty ſeems ſtill to be as great as it was in the time of Franklin.

‡ ÆPINUS has applied a very elaborate ſyſtem of mathematical reaſoning to the ſolution of electrical phænomena, and has adopted as the baſis of his theory, the ſame opinion which Franklin had entertained concerning the nature of the electric fluid; but he has combined with this opinion other principles ſo inadmiſſible, that his reaſonings cannot be regarded as juſt explications of the phænomena. He has aſſumed, apparently without any other reaſon than its importance to his concluſions, that the particles of all other ſubſtances repel each other. His ſyſtem muſt therefore be conſidered, not as a phyſical ſolution agreeable to the known laws of natural operations, but merely as an ingenious exerciſe of mathematical ability.

M. DE LUC, who rejected the ſolutions of Æpinus has endeavoured to ſupply the deficiency. § Having remarked that the divergence

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* Dr. Prieſtley's Hiſtory of Electricity, p. 165. † Ibid. p. 492.

‡ Journal de Phyſique, Dec. 1787. § Journal de Phyſique, Juin 1790.

divergence of the balls of an electrometer, included in the receiver of an air-pump, is continually diminiſhed during the progreſs of exhauſtion; he conſiders it as proved, that the cauſe of all electrical movements, whether of attraction or of repulſion, is the action of the air. This principle he applies in the following manner. When two bodies are in ſimilar ſtates of electricity, either poſitive or negative, they will conſpire to modify, either by giving or receiving the electric fluid, the ſtate of the intermediate air, whilſt that of the exterior air is only modified by either of them ſingly; and therefore the ſtate of the exterior air will differ more from that of the electrified bodies, than the ſtate of the intermediate air. In this caſe he contends that a repulſion muſt take place, becauſe each body muſt move towards that part of the ſurrounding medium, whoſe electrical ſtate is moſt different from its own. On the other hand, when bodies are in different ſtates of electricity, they will mutually counteract the changes, which they might ſeparately produce in the ſtate of the intermediate air; but each will operate on the exterior air without any compenſation. In this caſe the ſtate of the intermediate air will continue to differ from that of each body as much as at the firſt inſtant, whilſt the ſtate of the exterior air is ſeparately modified by each body according to its reſpective ſtate of electricity. The two bodies therefore, moving towards that part of the ſurrounding medium, whoſe electrical ſtate is moſt different from their own, will at the ſame time move towards each other.

This theory very ingeniouſly avoids the difficulty of explaining the caſe of electrical repulſion, by reſolving it into an attraction towards the ſurrounding medium. It ſeems however to be liable to two objections. In the firſt place, inſtead of aſſuming unauthorized principles with the preceding theory, it omits the conſideration of one whoſe exiſtence ſeems to be aſcertained by experiments. If a body be in either ſtate of electricity, it will induce in an adjacent body the contrary ſtate, until it ſhall have come within a certain diſtance. This property, which has been aſcertained by various experiments, indicates a repulſive force ſubſiſting between the portions of the electric fluid that belong to the adjacent bodies; and this theory makes no allowance for ſuch a repulſion. The fundamental principle of it is merely a diffuſion of the electric fluid, and is * thus ſtated by M. De Luc: "the electric matter tends towards all ſubſtances, and the more ſtrongly in the ſame proportion in which they poſſeſs a ſmaller quantity." In the ſecond place, it does not appear, when carefully conſidered, to afford any aſſiſtance towards the removal of the grand difficulty, the mutual repulſion of bodies negatively electrified. If two bodies negatively electrified be placed at a ſmall diſtance, they will both, according to M. De Luc's explanation, receive the electric fluid from the intermediate air, which will conſequently retain a ſmaller portion than the ſurrounding atmoſphere. From the law above-mentioned it ſhould follow, that the redundant fluid of the exterior air ſhould by diffuſion

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* "La loi ſuivante ſuffit ſeule: La matière électrique tend vers toutes les ſubſtances, d'autant plus fortement, qu'elles en poſſèdent moins." Journal de Phyſique, Juin 1790.

diffuſion be communicated both to the bodies and to the intermediate ſpace; but no reaſon appears, which would induce us to ſuppoſe that the bodies themſelves ſhould recede to a greater diſtance. M. De Luc does indeed endeavour to prove that ſuch a motion ſhould take place, but by an experiment whoſe ſolution contradicts his own theory. He ſuſpended by a ſilk thread a large, but light, metallic ball, and preſented it in a ſtate of poſitive electricity to a body negatively electrified. The former was attracted towards the latter until it arrived at a certain diſtance, at which it diſcharged its electricity. Hence he concluded, in general, that when a body has more of the electric fluid than the neighbouring bodies, and is leſs diſpoſed to reſiſt its own motion than to abandon the exceſs of its electric matter, it will move towards that place which contains leſs of this matter. But in this experiment he conſiders the two bodies as acting on each other at a diſtance without any reference to the intermediate air.

Mr. Cavallo*, in the laſt edition of his treatiſe on electricity, has obſerved, that the mutual repulſion of two bodies negatively electrified is ſtill ſuppoſed to contradict the theory of Franklin; and has therefore deemed it neceſſary to obviate the objection by a very particular detail. For this purpoſe he has premiſed the following propoſitions. Prop. 1. No electricity can appear on the ſurface of a body, or no body can be electrified either poſitively or negatively,

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* Vol. III. p. 192.

negatively, unleſs the contrary electricity can take place on other bodies contiguous to it. Prop. 2. There is ſomething on the ſurface of bodies, which prevents the ſudden incorporation of the two electricities, viz. of that poſſeſſed by the electrified body with the contrary electricity poſſeſſed by the contiguous air, or other ſurrounding bodies. Prop. 3. Suppoſing that every particle of a fluid has an attraction towards every particle of a ſolid; if the ſolid be left at liberty in a certain quantity of that fluid, it will be attracted towards the common centre of attraction of all the particles of the fluid. To this laſt propoſition he has ſubjoined the two following corollaries: 1.* the ſame thing muſt happen, when the quantity of fluid is ſmaller than the bulk of the body; 2. if the attraction of the particles of the fluid be exerted only towards the ſurface of the ſolid, the effect will be the ſame when the body is of a regular ſhape; but the difference will in any caſe be inconſiderable.

With regard to the ſolution founded upon theſe principles it muſt be remarked, that it is not derived ſimply from a conſideration of the ſuppoſed nature of the electric fluid; but from a mixed ſtatement of that nature and of properties aſſumed merely from experiments as matters of fact. The firſt and ſecond propoſitions expreſs thoſe properties, and, though the experiments to which the former refers, may be explained by aſcribing the phænomena to the repulſive nature of the fluid, yet the latter is aſſumed "without

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* Of this corollary Mr. Cavallo does not appear to make any diſtinct application.

without any ſuch reference. "Without examining," ſays Mr. Cavallo, "the nature, the extent, and the laws of this property in bodies, "it will be ſufficient for the preſent purpoſe to obſerve, that the "fact is certainly ſo; for otherwiſe a body could not poſſibly be "electrified, or it would not remain electrified for a ſingle moment." From theſe principles thus aſſumed, Mr. Cavallo deduces the exiſtence of atmoſpheres of contrary electricity exiſting in the air contiguous to the bodies; and from the attractions which are thereby occaſioned he infers the apparent repulſion of the electrified bodies.

If theſe atmoſpheres be conceived to be formed by the repulſive nature of the fluid, ſome allowance ſhould be made for the mutual repulſion of the two redundant portions belonging to bodies poſitively electrified. This however ſeems to be neglected for the purpoſe of explaining the repulſion of bodies negatively electrified. But the difficulty ſeems to be only changed. If the negative atmoſphere adjacent to a body poſitively electrified be cauſed by the repulſion of the redundant fluid of the body, it will be neceſſary to ſhew that this repulſion is overpowered by the attraction ſubſiſting between that redundant fluid and the portion of air thus deprived of a part of its electric fluid.

But the reality of theſe atmoſpheres of contrary electricity may well be queſtioned. It ſeems to require, that we ſhould conceive a portion of air contiguous to each body to be permanently, during the mutual repulſion of the bodies, in a ſtate of electricity oppoſite to that of the bodies. But * it is aſcertained experimentally, that the air ſurrounding any electrified body acquires the ſame electricity which had been poſſeſſed by the body, and retains it even after the removal of the body. This muſt be ſuppoſed, agreeably to the known laws of electricity, to be communicated by the alternate attraction and repulſion of the adjacent particles of air. Each particle muſt be firſt attracted towards the body, and, when by contact it has acquired the electricity of the body, repelled from it. Inſtead therefore of a permanent ſtate of contrary electricity conſtituting theſe ſuppoſed atmoſpheres, each adjacent ſpace muſt be occupied by particles, ſome of which are attracted and others repelled. The time requiſite for thus reducing the electricity of the body to an equilibrium with that of the ſurrounding air, is ſufficient for explaining the continuance of the electricity of the bodies, without the aid of the ſecond propoſition; and the firſt propoſition is deduced only from a conſideration of bodies in a ſolid ſtate.

POSSIBLY a more diſtinct application of a principle, already in ſome degree adopted both by Doctor Prieſtley and Mr. Cavallo, may remove all the difficulties of this inquiry. At leaſt I will hope, that it may lead to ſuch a conſideration of the queſtion, as may ſubject the merits of the theory itſelf to a fair and deciſive diſcuſſion.

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* Cavallo's Complete Treatiſe on Electricity, Vol. I. p. 326.

diſcuſſion. This principle is ſaturation. * Doctor Prieſtley has explained the communication of the redundant fluid of a body poſitively electrified to another, a part of whoſe fluid had been previouſly expelled, by ſuppoſing that it was more ſtrongly attracted by the other body, than by its own which had more than its natural ſhare; and † Mr. Cavallo has in the ſame manner accounted for the mutual attraction of bodies in different ſtates of electricity.

I applying this principle to the ſolution of electric phænomena three forces muſt be conſidered: 1ſt, the attraction ſubſiſting between each body and its own portion of the electric fluid; 2dly, the attraction which may ſubſiſt between each body and the portion of fluid belonging to the other; and 3dly, the repulſion ſubſiſting between the two portions of the electric fluid.

THAT the attraction ſubſiſting between two bodies in oppoſite ſtates of electricity may be explained, it is neceſſary to conſider previouſly the caſe of two bodies in their natural or ordinary ſtate. In this caſe the force ſubſiſting between each body and its own portion of the electric fluid is not in a ſtate of ſaturation, becauſe it muſt be ſufficiently ſtrong to counterbalance the elaſticity of the fluid. Each body is therefore ſtill capable of being attracted by the fluid belonging to the other, and each portion of the fluid is alſo capable of ſuch attraction This force, if it ſhould operate

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* Hiſtory of Electricity, p. 253. † Vol. I. p. 109.

alone, would draw the bodies together; but the mutual repulſion of the two portions of the fluid tends to produce the oppoſite effect. The quieſcence of the bodies proves the equality of theſe forces.

If two bodies in oppoſite ſtates of electricity be brought together, the body poſitively electrified cannot be attracted towards the remaining electric fluid belonging to the other, becauſe this body may be conſidered as ſaturated with the fluid, and that portion of the fluid as ſaturated with ſolid matter. For the oppoſite reaſons an attraction will take place between the body negatively electrified and the fluid belonging to the former. It remains to be ſhewn, that this attractive force may exceed the mutual repulſion of the two portions of fluid. It muſt be obſerved, that the repulſion remains the ſame, becauſe the ſum of the two quantities of fluid is not altered; whereas the attraction is augmented by the unequal diſtribution of the fluid. The one body is charged with more fluid than that which its own attracting force is capable of retaining, and the redundant fluid will conſequently be ſtrongly impelled towards the other body, whoſe attractive power is at the ſame time increaſed by the deficiency of its own portion of fluid.

In the caſe of two bodies ſimilarly electrified the bodies may be either both poſitively, or both negatively electrified. When they are both poſitively electrified, they are both ſaturated with the electric fluid; and when they are both negatively electrified, both

both remaining portions of the electric fluid are reciprocally ſaturated with ſolid matter. In neither caſe therefore can any attraction take place between either body and the fluid belonging to the other. Conſequently, the repulſion exiſting between the two portions of the fluid muſt operate without reſiſtance, and the two bodies be repelled from each other.

SHOULD this ſolution of electric attraction and repulſion be admitted, it will perhaps alſo remove the difficulty of magnetic repulſion. In this part of philoſophy it has been found difficult to explain the repulſion of the correſponding poles agreeably to the theory of a magnetic fluid. In every magnetical body the equilibrium of this fluid is ſuppoſed to be diſturbed, and one part of the body is conceived to be overcharged with the fluid, whilſt the other is undercharged. The difficulty was to explain the repulſion of the undercharged poles, as in electricity to explain the repulſion of bodies negatively electrified. Mr. Kirwan has indeed, in a Memoir contained in the Sixth Volume of the Tranſactions of the Academy, referred the phænomena of magnetiſm to cryſtallization; but his mention of the term *ſaturated* in that Memoir ſeems to imply, that he does not mean to exclude the ſuppoſition of a magnetic fluid. If this be adopted, the preceding ſolution may be applied to the phænomena of magnetiſm, in the ſame manner in which it has been already applied to thoſe of electricity.

THE theory, according to which the preceding ſolution has been propoſed, ſuppoſes the electric fluid a *ſingle* fluid; but it is not neceſſary

ceſſary that it ſhould be conceived to be abſolutely *ſimple.* We know, for inſtance, that atmoſpheric air is a combination of at leaſt two diſtinct fluids; and yet explain the phænomena of the barometer, air-pump, and condenſer, as depending merely on its preſence or abſence, without any reference to the compoſition of its nature. In the ſame manner ſome electric phænomena may be juſtly explained by conſidering them as the effects of the different diſtribution of the ſame fluid; whilſt its phoſphoric ſmell, its power of changing blue vegetable colours to red, and its combuſtion may poſſibly be derived from its decompoſition.